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EFFECTS OF PINE-OAK CLEARCUTTING ON WINTER AND BREEDING BIRDS IN SOUTHWESTERN VIRGINIA

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Clearcutting is a quick and economical method of obtaining needed timber. Many groups, however, oppose clearcutting because of aesthetic reasons, erosion, and effects on wildlife. At present, there is little information available to determine the impact of clearcutting on many wildlife species.

Most studies of succession and bird populations in hardwood forests have reported a general increase in bird species richness and density with increasing age of the sere: Michigan (Kendeigh 1944), North Carolina (Odum 1950), Georgia (Johnston and Odum 1956), Illinois (Karr 1968), and Arkansas (Shugart and James 1973). In contrast, Bond (1957) observed the highest number of species at intermediate stages of succession in Wisconsin.

The gradual trend toward an increase in bird species diversity in southeastern deciduous forests reported by Johnston and Odum (1956) and Shugart and James (1973) was not observed by Conner and Adkisson (1975) in seral stages of regenerating clearcuts in southwestern Virginia. Conner and Adkisson (1975) observed highest breeding bird diversity and numbers in clearcuts 3 to 12 years old. Similar results were also found by Ambrose (1975) in 3-year-old Tennessee clearcuts and in clearcuts up to 6 years old in Southwestern Virginia (Hooper 1967). This is in contrast to what would have been predicted by correlations between foliage height diversity and bird species diversity (MacArthur and MacArthur 1961). The 3- to 12-year-old clearcuts in the study by Conner and Adkisson (1975) included areas of sparse and dense vegetation because of extensive stump sprouting. Where such patchy conditions occur, bird species diversity is no longer solely dependent on foliage height diversity (MacArthur 1964).

Few studies exist on the effect of even-aged management on bird populations in coniferous forests. Studies of succession in coniferous forests and bird populations indicate that bird species diversity increases with age of the sere. Johnston and Odum (1956) reported an increase in number of species, density of breeding pairs, and diversity as the age of the pine (*Pinus* spp.) forest stage of old field succession increased. Peak bird density occurred in mature pine forests where the understory was not inhibited. Haapanen (1965) also reported that breeding bird density and species richness reached a maximum in climax pine stands in Finland. However, species richness was highest in the middle stages of succession of Douglas-fir

(*Pseudotsuga menziesii*) in Oregon (Meslow and Wight 1975). Hole-nesters increased in numbers as the age of the Douglas-fir seres increased.

Our study was designed to see if numbers and diversity of birds in regenerating pitch pine (*Pinus rigida*)-oak (*Quercus* spp.) clearcuts followed successional patterns similar to other coniferous communities (Johnston and Odum 1956, Haapanen 1965) or whether they were different as in regeneration of oak-hickory (*Carya* spp.) clearcuts (Conner and Adkisson 1975). We were also interested in determining the net effect of pine-oak clearcutting on bird populations.

THE STUDY AREAS

Four habitat ages were selected for the study: 3-year-old clearcuts (mean basal area [BA]: 0.8 m^2/ha, vegetation height [VH]: 1.5 m, mean density of stems [DS]: 91.7 stems > 7 cm DBH [diameter at breast height]/ha); 10-year-old clearcuts (BA: 9.2 m^2/ha, VH: 3.5 m, DS: 5395.8 stems > 7 cm DBH/ha); 30-year-old stands (BA: 23.3 m^2/ha, VH: 7.0 m, DS: 3025.0 stems > 7 cm DBH/ha); and mature 80-year-old stands (BA: 36.1 m^2/ha, VH: 20.0 m, DS: 1075.3 stems > 7 cm DBH/ha) (N = 16 for vegetation measurements in each age class). The rectangular study areas, ranging between 20 and 30 ha, were located in the Jefferson and George Washington National Forests. The study areas were typical of the habitat conditions created by cleareutting in the pine-oak timber type of southwestern Virginia. For white pines (*Pinus strobus*), the site index (height in feet that white pines will grow in 50 yrs) in the study areas was around 70. The study areas faced southwest to southeast and were at elevations between 580 and 620 m above sea level. All areas were pitch pine-oak forest type. The most dominant tree species in order of abundance were pitch pine, chestnut oak (*Quercus prinus*), table-mountain pine (*Pinus pungens*), northern red oak (*Quercus rubra*), white pine, white oak (*Q. alba*), and red maple (*Acer rubrum*). Sassafras (*Sassafras albidum*), mountain-laurel (*Kalmia latifolia*), and *Vaccinium* spp. were interspersed throughout the areas.

No site preparation had been done on the clearcut areas prior to planting of pine seedlings. There were no records of, nor could we find any evidence of herbicide application on any of the study areas. Although several pines of 10 cm DBH or more were left standing in each cut area, there were no obvious cavities in snags or live trees for cavity nesting birds. Degrees of cover in the understory can best be seen in photos of each area: 3-year-old (Fig. 1), 10-year-old (Fig. 2), 30-year-old (Fig. 3), 80-year-old (Fig. 4).

METHODS

Four 100 m transects were located in each of the 4 seral stages. Bird species and numbers were censused by counting all birds seen or heard within 25 m of either side of the transect. Care was taken not to census any bird twice; a minimum of 20 min was spent sampling each transect. Transect sample methods have been used in other studies which involved censusing breeding birds in coniferous stands of different ages (Haapanen 1965). If factors other than bird population differences have minimal effect on within and among variation, transect sampling provides excellent data to obtain relative differences between levels of treatment. Absolute measures of bird populations are not needed, and are actually unattainable. The transect method is also an efficient means

FIG. 1. The 3-year-old study area.

of sampling avian populations during breeding and non-breeding seasons (Emlen 1971). Although not as thorough, bird population estimates from transect counts compare favorably with the more tedious spot map method (Graber and Graber 1963, Franzreb 1976). The spot map method is applicable only during the breeding season (Franzreb 1976).

The 16 transects were each sampled 6 times each season. This yielded 24 samples of each seral stage for the winter, and breeding season. Winter birds were censused

FIG. 2. The 10-year-old study area.

between 08:00 and 12:00 EST from January to March 1976. Breeding birds were censused between 06:00 and 10:00 EST during May and June 1976. Sampling times for each area were rotated so that all transects were sampled at all times available in the censusing time period.

We felt 6 replications of each census provided an accurate estimate of the birds in the transects. Several studies have shown that with 4 replications 96% of the bird species in an area were sampled at least once (Palmgren 1930, Dobrakhotov 1961). Our extended sampling period for each season allows for maximum opportunity to sample for all possible winter residents or breeding birds (Kendeigh 1944, Emlen 1971).

Relative abundance and an index of bird species diversity were calculated using the Shannon information formula (Shannon 1948). These values were calculated for each seral stage during both seasons of the study. The Shannon formula is an index for species diversity (H′) which has 2 major components: the number of species or species richness (S) and the evenness of species distributions or equitability (J′) (Tramer 1969). Species richness typically increases as the structural diversity of the habitat increases (MacArthur and MacArthur 1961). Equitability (J′) of bird populations is affected by factors causing changes in spatial arrangements of birds. Typically, equitability is higher during breeding seasons when birds are more evenly spaced due to territoriality and lower during winter when many feeding flocks are formed (Tramer 1969, Kricher 1972).

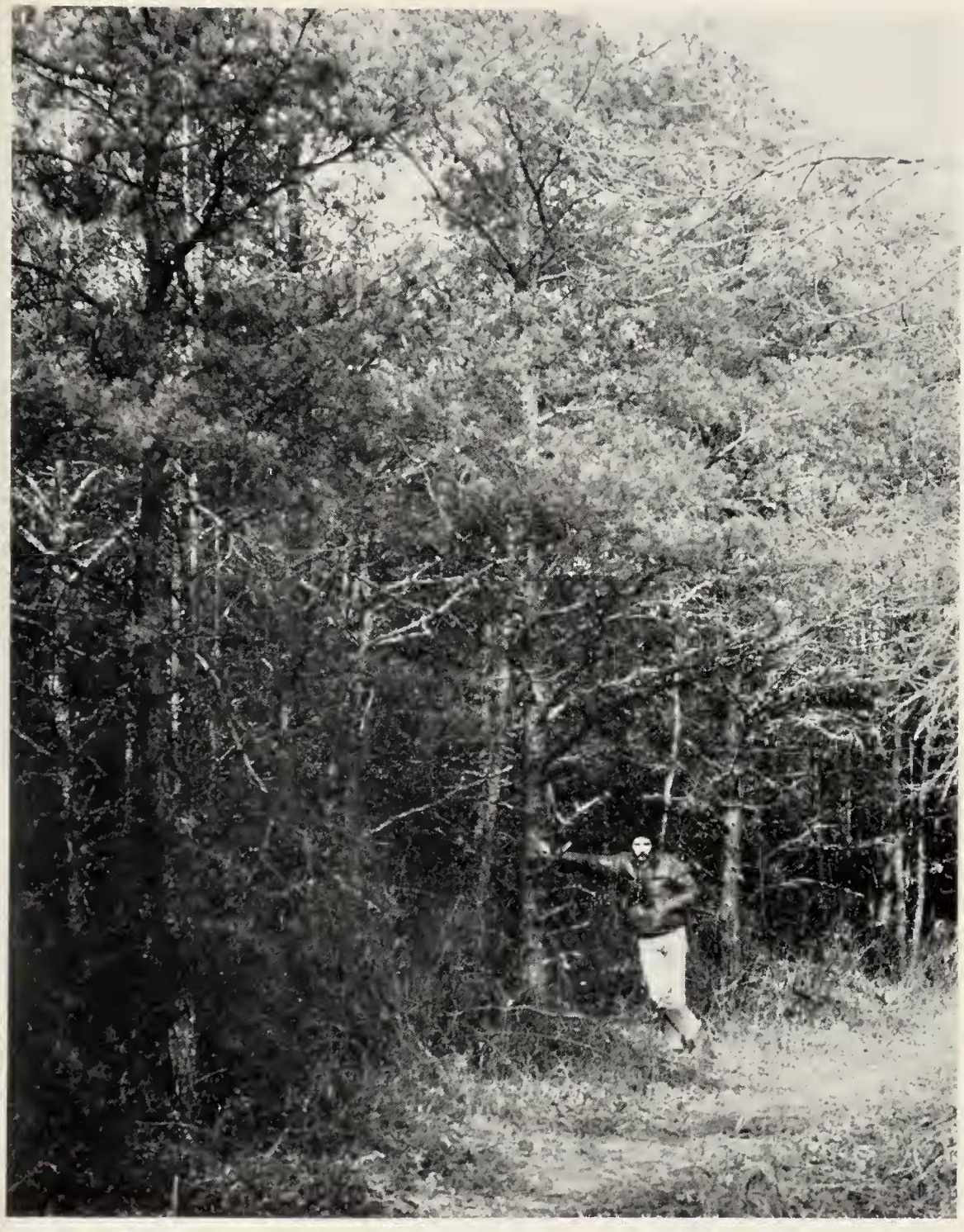

FIG. 3. The 30-year-old study area.

Tests of the data detected minor deviations from normality. Results of non-parametric 1-way ANOVA (Kruskal-Wallis) and parametric ANOVA revealed the parametric technique to be the more rigorous test. When statistical assumptions can be approximately met, use of parametric techniques rather than non-parametric ones is recommended (Sokal and Rohlf 1969).

FIG. 4. The 80-year-old study area.

RESULTS

Winter

During the winter, bird species diversity and number of birds seen in the 3-year-old pine-oak clearcuts were significantly lower than in the other 3 habitat conditions ($P \leq 0.01$, Duncan's New Multiple Range Test). Bird

Table 1

Relative Abundance of Bird Species in the 4 Study Areas During the Winter Season

Bird species	3-year-old clearcuts	10-year-old clearcuts	30-year-old stands	Mature stands
Dark-eyed Junco (*Junco hyemalis*)	0.143	0.011		0.005
Black-capped Chickadee (*Parus atricapillus*)	0.286		0.022	0.207
Carolina Chickadee (*Parus carolinensis*)	0.571	0.347	0.389	0.174
Yellow-rumped Warbler (*Dendroica coronata*)		0.011		
Golden-crowned Kinglet (*Regulus satrapa*)		0.274	0.156	0.131
Red-breasted Nuthatch (*Sitta canadensis*)		0.168	0.144	0.131
Tufted Titmouse (*Parus bicolor*)		0.032	0.078	0.047
Blue Jay (*Cyanocitta cristata*)		0.032	0.044	0.005
Fox Sparrow (*Passerella iliaca*)		0.042		0.014
Red Crossbill (*Loxia curvirostra*)		0.021	0.089	0.080
Common Crow (*Corvus brachyrhynchos*)		0.011		0.005
Downy Woodpecker (*Picoides pubescens*)		0.021	0.022	0.023
Cardinal (*Cardinalis cardinalis*)		0.011		0.009
White-breasted Nuthatch (*Sitta carolinensis*)		0.011	0.011	0.066
Pileated Woodpecker (*Dryocopus pileatus*)		0.011		0.009
Common Graekle (*Quiscalus quiscala*)			0.033	
Hermit Thrush (*Catharus guttata*)			0.011	
Carolina Wren (*Troglodytes ludovicianus*)				0.019
Ruby-crowned Kinglet (*Regulus calendula*)				0.005
Brown Creeper (*Certhia familiaris*)				0.019

TABLE 1 (continued)

Bird species	3-year-old clearcuts	10-year-old clearcuts	30-year-old stands	Mature stands
Pine Warbler (*Dendroica pinus*)				0.047
Winter Wren (*Troglodytes troglodytes*)				0.005
Number of birds	14	95	90	213
Species diversity (H′)	0.96	1.82	1.87	2.34
Number of species (S)	3	14	11	19
Equitability (J′)	0.874	0.690	0.780	0.795

species diversity and numbers of birds seen in the mature pine areas during the winter were significantly higher than in the other 3 habitat conditions ($P \leqslant 0.01$). There were no significant differences between the 10- and 30-year-old clearcuts. Equitability index values (J′) of bird species distribu-

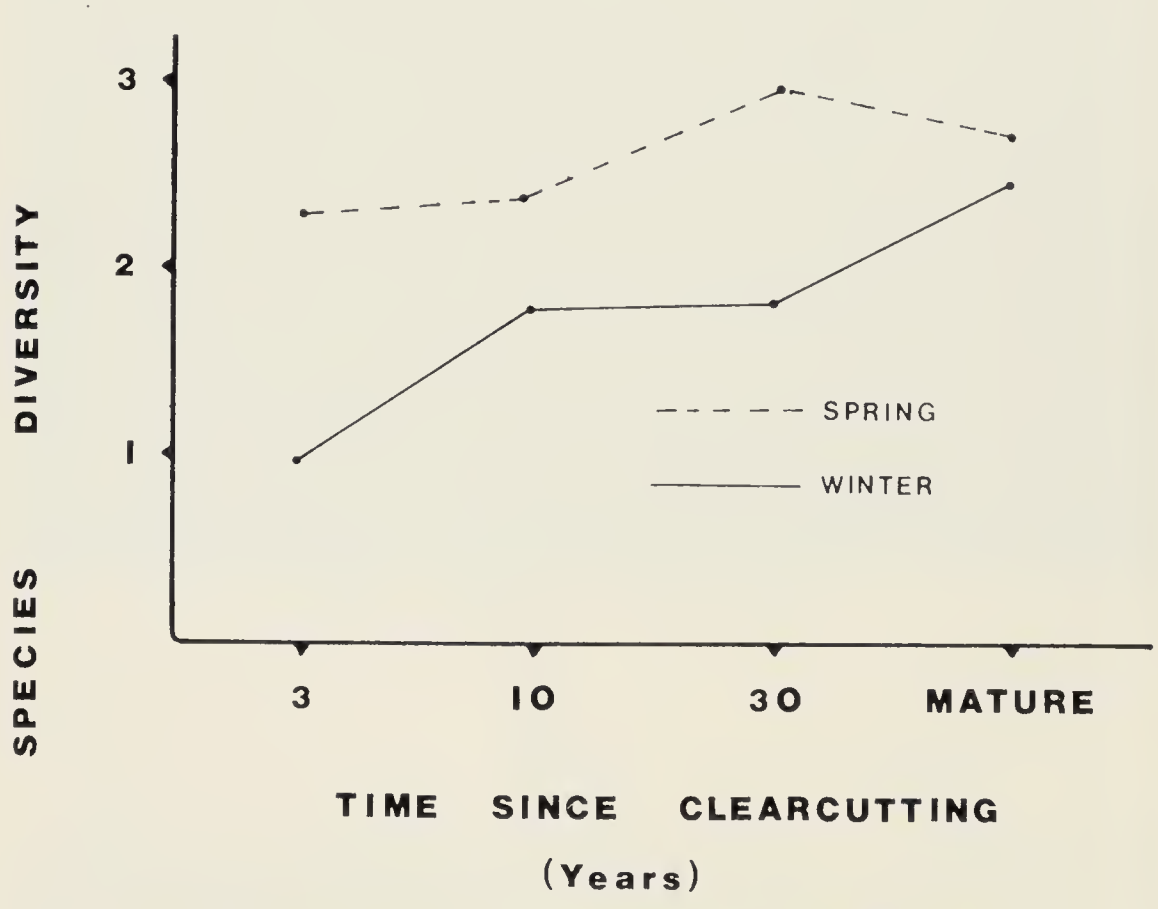

FIG. 5. Bird speeics diversity in the winter and breeding seasons.

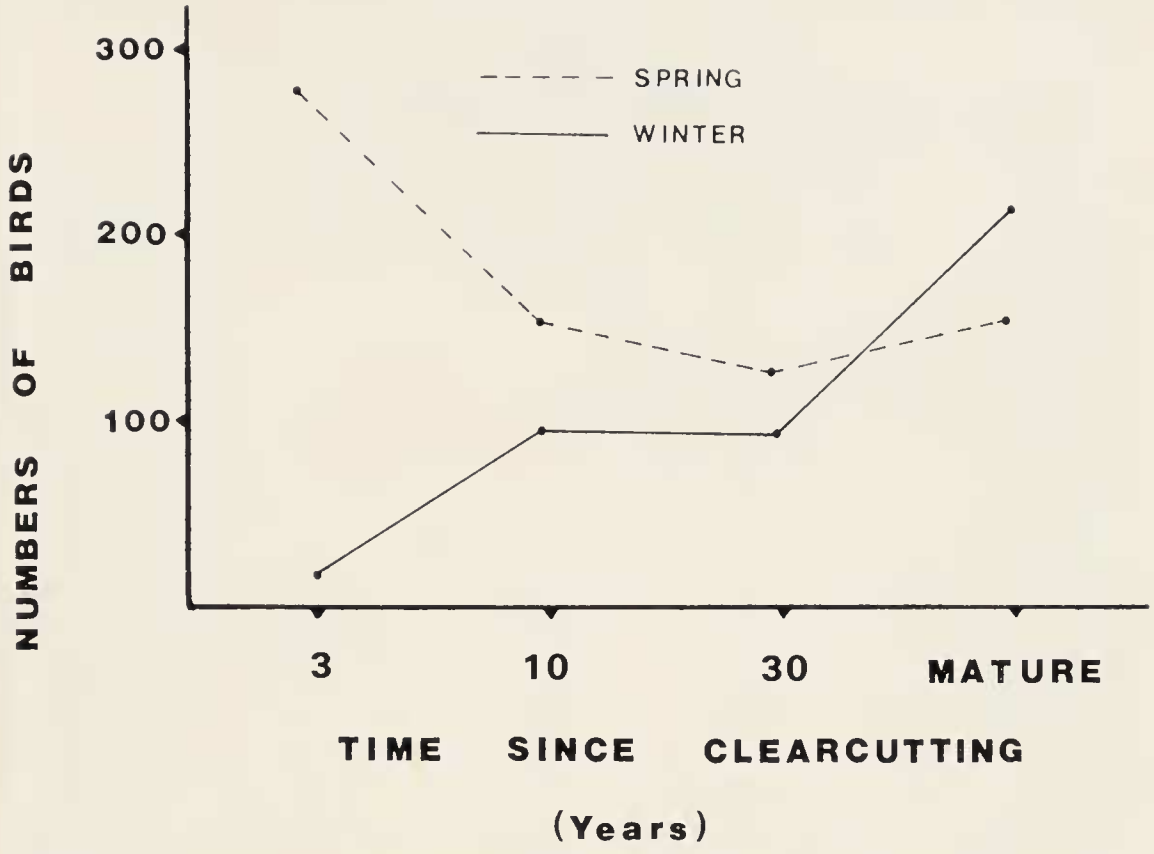

FIG. 6. Total number of birds seen or heard in the winter and breeding seasons.

tion showed an increasing trend (increasing evenness of bird species distribution) except for the 3-year-old area (Table 1).

Three-year-old clearcuts.—This area had the lowest winter bird species diversity (0.96) (Fig. 5), with a total of only 3 species (Table 1). A total number of 14 birds was seen in this area during the winter season (Table 1). Winter birds probably avoided this habitat condition because it did not provide the needed cover and food resources.

Ten-year-old clearcuts.—Carolina Chickadees (see Tables 1 and 2 for scientific names) and Golden-crowned Kinglets used this habitat condition regularly (Table 1). Red-breasted Nuthatches were also seen often. Winter bird species diversity was 1.82 (Fig. 5) and a total of 95 birds (Fig. 6) of 14 species (Table 1) was seen.

Thirty-year-old stands.—As in the 10-year-old clearcuts, Carolina Chickadees, Golden-crowned Kinglets, and Red-breasted Nuthatches were the most abundant species (Table 1). Winter bird species diversity was 1.87 (Fig. 5), and we observed a total of 90 birds (Fig. 6) of 11 species (Table 1).

Mature stands.—Black-capped Chickadees, Carolina Chickadees, Golden-crowned Kinglets, and Red-breasted Nuthatches occurred regularly in the mature stands. Red Crossbills and White-breasted Nuthatches were seen

Table 2

Relative Abundance of Bird Species in the 4 Study Areas During the Breeding Season

Bird species	3-year-old clearcuts	10-year-old clearcuts	30-year-old stands	Mature stands
White-eyed Vireo (*Vireo griseus*)	0.007			
Great Crested Flycatcher (*Myiarchus crinitus*)	0.014			
Yellow-breasted Chat (*Icteria virens*)	0.069			
Field Sparrow (*Spizella pusilla*)	0.025			
Common Flicker (*Colaptes auratus*)	0.011	0.006		
Prairie Warbler (*Dendroica discolor*)	0.134	0.056	0.025	
Indigo Bunting (*Passerina cyanea*)	0.174	0.025	0.008	
Goldfinch (*Spinus tristis*)	0.080	0.125	0.085	
Chestnut-sided Warbler (*Dendroica pensylvanica*)	0.007	0.031	0.017	
Cardinal (*Cardinalis cardinalis*)	0.007		0.008	0.013
Hooded Warbler (*Wilsonia citrina*)	0.014	0.031	0.085	0.013
Gray Catbird (*Dumetella carolinensis*)	0.058	0.019	0.008	0.058
Rufous-sided Towhee (*Pipilo erythrophthalamus*)	0.322	0.406	0.144	0.213
Brown-headed Cowbird (*Molothrus ater*)	0.036	0.075	0.051	0.013
Carolina Wren (*Troglodytes ludovicianus*)	0.014		0.025	0.006
American Robin (*Turdus migratorius*)	0.014			0.006
Downy Woodpecker (*Picoides pubescens*)	0.007	0.013	0.017	0.019
Carolina Chickadee (*Parus carolinensis*)	0.004	0.088	0.127	0.168
Brown Thrasher (*Toxostoma rufum*)		0.013	0.017	
Cedar Waxwing (*Bombycilla cedrorum*)		0.013		
Blue Jay (*Cyanocitta cristata*)		0.006	0.059	0.026

TABLE 2 (continued)

Bird species	3-year-old clearcuts	10-year-old clearcuts	30-year-old stands	Mature stands
White-breasted Nuthatch (*Sitta carolinensis*)		0.006	0.017	0.006
Pine Warbler (*Dendroica pinus*)		0.025	0.076	0.142
Wood Thrush (*Hylocichla mustelina*)		0.006		0.032
Black-and-white Warbler (*Mniotilta varia*)		0.031	0.034	0.006
Blue-gray Gnatcatcher (*Polioptila caerulea*)		0.013	0.059	0.026
Tufted Titmouse (*Parus bicolor*)		0.006	0.042	0.019
Eastern Phoebe (*Sayornis phoebe*)			0.008	
Red Crossbill (*Loxia curvirostra*)			0.034	0.013
Acadian Flycatcher (*Empidonax virescens*)			0.017	0.006
Ovenbird (*Seiurus aurocapillus*)			0.025	0.097
Common Grackle (*Quiscalus quiscala*)			0.008	0.006
Pileated Woodpecker (*Dryocopus pileatus*)				0.013
Hairy Woodpecker (*Picoides villosus*)				0.019
Red-eyed Vireo (*Vireo olivaceus*)				0.026
Louisiana Waterthrush (*Seiurus motacilla*)				0.013
Common Crow (*Corvus brachyrhynchos*)				0.013
Scarlet Tanager (*Piranga olivacea*)				0.019
Yellow-billed Cuckoo (*Coccyzus americanus*)				0.006
Number of birds	276	160	118	155
Species diversity (H′)	2.16	2.19	2.83	2.64
Number of species (S)	18	21	24	27
Equitability (J′)	0.747	0.916	0.891	0.801

often (Table 1). Winter bird species diversity was the highest in the mature stands (2.34) (Fig. 5). We observed a total of 213 birds (Fig. 6) of 19 species (Table 1). The mature pine-oak forest apparently provided the best winter cover and food source of the 4 habitat conditions examined.

Breeding Season

No significant differences in breeding bird diversity were detected among the different aged pine-oak stands ($P \leqslant 0.05$). The 3-year-old clearcuts had a significantly higher total number of birds than any of the other stands ($P \leqslant 0.01$). The index of equitability (J′) was higher in the intermediate stage of succession (10-year-old) when compared to the 3-year-old and mature stands. The highest index value occurred in the 10-year-old clearcut while the lowest was in the 3-year-old area (Table 2).

Three-year-old clearcuts.—Bird diversity and numbers were quite different during the breeding season from what they had been in the winter. Breeding bird species diversity was 2.16 (Fig. 5) with 18 species present (Table 2). A significantly greater number of birds (276) (Fig. 6) was seen in the 3-year-old clearcuts during the breeding season than in any of the other habitat conditions. Rufous-sided Towhees were extremely abundant in the 3-year-old clearcuts. Prairie Warblers, Indigo Buntings, American Goldfinches, and Yellow-breasted Chats were regularly observed (Table 2). The pines and dense deciduous growth apparently provided an abundant food supply and nesting sites for the bird species present.

Ten-year-old clearcuts.—Rufous-sided Towhees were the most abundant species in this habitat. American Goldfinches, Carolina Chickadees, Brown-headed Cowbirds, and Prairie Warblers were seen regularly (Table 2). Breeding bird species diversity (2.19) (Fig. 5) was similar to that observed in the 3-year-old clearcuts. A total of 160 birds (Fig. 6) of 21 species (Table 2) were seen in the 10-year-old clearcuts.

Thirty-year-old stands.—Rufous-sided Towhees and Carolina Chickadees were the most abundant species in the 30-year-old stands during the breeding season (Table 2). American Goldfinches, Hooded Warblers, and Pine Warblers were observed regularly. Breeding bird species diversity (2.83) (Fig. 5) and number of species (24) were higher in this habitat condition than in the 2 younger seral stages. However, the total number of birds seen (118) was the lowest of all the habitat conditions examined during the breeding season (Fig. 6).

Mature stands.—Rufous-sided Towhees, Carolina Chickadees, and White-breasted Nuthatches were the most abundant species in the mature stands (Table 2). Ovenbirds were seen regularly. Breeding bird species diversity

in the mature stands (2.64) (Fig. 5) was lower than observed in the 30-year-old stands. The mature stands had the highest number of species (27) of all the areas; a total of 155 birds was seen (Fig. 6).

DISCUSSION

Breeding bird diversity and species richness in regenerating pine-oak clearcuts increased with age of the stand. This is similar to the pattern observed in other conifer stands by Johnston and Odum (1956) and Haapanen (1965). This pattern was not observed in oak-hickory clearcuts where breeding bird diversity and species richness were highest in stands 3 to 12 years old (Hooper 1967, Ambrose 1975, Conner and Adkisson 1975).

The equitability index was higher in the breeding season than in winter in all areas except the 3-year-old clearcut (Tables 1 and 2). The higher values during the breeding season are expected due to increased territoriality, and lack of the unpredictable and rigorous environment of the winter season (Tramer 1969, Kricher 1972). The higher equitability index of the 3-year-old area in winter could be due to the sparse bird life present as a response to limited cover. Similar results were found in Kricher's (1972) early successional stage in winter.

As the age of the pine-oak habitat increased, we also observed a change in breeding bird species composition. Early succession species like Indigo Buntings, Prairie Warblers, Common Flickers, Field Sparrows, Yellow-breasted Chats, and White-eyed Vireos that were present in the younger areas, became less abundant as the age of the area increased, and were totally absent from the mature pine-oak stands. Other species were associated mainly with the older stands: Pine Warblers, Red Crossbills, Ovenbirds, Pileated Woodpeckers, Hairy Woodpeckers, and Scarlet Tanagers. Successional changes in bird species composition with successional changes in vegetation have been reported for other geographical areas (Johnston and Odum 1956, Meslow and Wight 1975).

Several species of birds that occurred only in the more mature areas were negatively affected by pine-oak clearcutting. Pileated Woodpeckers favored the older stands in both the winter and breeding seasons. This preference is similar to that observed in oak-hickory stands (Conner and Crawford 1974, Conner et al. 1975). Red Crossbills depend on an abundance of mature cones as they feed extensively on pine seeds; this species appeared to prefer the more mature stands during both seasons and would probably be severely affected by clearcutting in any pine forest.

In winter as the age of the area increased, there was a trend for an addition of new bird species without the loss of species seen in the younger

stands (Table 1). This was not a change in bird species composition as occurred during the breeding season (Table 2). Both total numbers of birds seen and bird species diversity in winter were severely reduced in the 3-year-old stands and gradually increased as the age of the area increased. From these observations, we concluded that pine-oak clearcutting reduced the capability of pine-oak habitat type to support winter bird populations.

Although bird species diversity was depressed, pine-oak clearcutting may have had a slightly beneficial effect on breeding bird populations of the total area being managed. In addition to a change in bird species composition between areas, there was a significant increase in numbers of birds in the 3-year-old clearcuts. This beneficial effect for breeding birds would probably only be realized if 2 conditions were met. Rotation time would have to be long enough to allow areas to reach 80+ years old to maximize the benefits to bird species that prefer a mature forest (Figs. 5 and 6). Rotation times this long are not economically beneficial for timber production in this timber type. Also, we speculate that a limitation may have to be put on the size of the area cut so that the entire area being managed is composed of many smaller subsets of different seral stages. Based on information in the literature, 10 ha is a large enough area to include most common species of birds in Georgia (Johnston and Odum 1956) and in mixed oak forests of New Jersey (Galli et al. 1976). Clearcuts no larger than 12–16 ha in size should be large enough to include most species of birds with the exception of those that have large home range requirements like the Pileated Woodpecker (at least 40 ha) (Tanner 1942).

Further research is needed to demonstrate the effects of even-aged management in other timber types. Eastern Bluebirds (*Sialia sialis*) nest in the younger regeneration stages of oak-hickory clearcuts (Conner and Adkisson 1974). We did not observe bluebirds in any of the pine-oak clearcuts even though the present study areas were in the same geographical area. Hairy Woodpeckers also foraged and nested in young oak-hickory clearcuts (Conner and Crawford 1974, Conner et al. 1975). In the present study, none were observed in the younger pine-oak clearcuts.

Pine-oak clearcutting can be beneficial or harmful to bird populations depending on the season, the seral stage, and the species of bird in question. If an area is to be managed under a multiple use policy, the factors concerning birds and other wildlife, in addition to timber needs, must be considered. There are always trade-offs in land management decisions; any management will have positive and negative effects. On viewing our results, we have concluded that the net effect of pine-oak clearcutting on birds in southwestern Virginia is negative.

SUMMARY

In pitch pine-oak stands in southwestern Virginia, winter species diversity and numbers of birds were lowest in the 3-year-old clearcuts and highest in the mature stands. Clearcutting reduced winter bird populations in all stages of pine-oak regeneration examined. There were no significant differences in bird species diversity among any of the study areas during the breeding season. The 3-year-old clearcuts had a higher number of birds during the breeding season than the other 3 differently aged areas. Species composition of breeding birds changed as the pine-oak stands regenerated toward maturity. When compared to the mature stands the net effect of pine-oak clearcutting on birds was negative.

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